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Short communication

Static magnetic field exposure improves germination and vigour of fresh and carry over seeds of garden pea

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ABSTRACT

An experiment was conducted at Nuclear Research Laboratory, IARI, New Delhi to find out the appropriate dose of magnetic field energy for fresh garden pea breeder seed of variety 'Bonneville'. Electromagnetic field strength (50 to 500 mT) was applied to fresh and aged seeds Among the treaments, 100 mT for 1 h exposure was found to the best and was able to bring back the vigour to the level of fresh seeds. The increase over the unexposed aged seed was 3.5% for germination, 40.3% for seeding length, 35.9% for seeding dry weight.

Key words: *Pisum sativum*, static magnetic field, seed vigour, natural ageing.

Ageing is a natural phenomenon which is generally irreversible resulting in seed deterioration. This process is hastened under poor storage conditions of high temperature and high humidity and the seed loses its viability and vigour. In the seed production chain, non-lifting of breeder seeds by indented agencies and over production of seeds in some years leads to storage and subsequent use of carry over seeds. Even with the advent of controlled storage facilities, sometimes, the seed germination falls below the minimum standard resulting in rejection of costly breeder seeds. Our earlier work has clearly demonstrated the positive effect of pre-sowing exposure of seeds to static magnetic field on germination and field emergence characteristics in a number of crops (Vashisth and Nagarajan, 10). Also, it was found that the appropriate magnetic field and exposure time had improved the germination and vigour of artificially aged seeds of maize, chickpea and sunflower (Vashisth, 9). Therefore, an experiment was conducted to evaluate the efficacy of magnetic field treatment in ameliorating the deterioration caused by ageing in carry over (2004 produce) seeds of garden pea variety 'Bonneville'.

Initial experiments were conducted at NRL, IARI, New Delhi to find out the appropriate dose of magnetic field energy for fresh breeder seed of garden pea variety 'Bonneville' of 2009 harvest obtained from IARI Regional station, Karnal. An electromagnetic field generator "Testron EM-20" with variable magnetic field strength (50 to 500 mT) with a gap of 5 cm between pole pieces was used. The seeds were exposed to different magnetic fields in a cylindrical shaped sample holder of 42 cm^3 capacity, made of non-magnetic thin transparent plastic sheet. Visibly undamaged seeds were exposed to magnetic fields of 50, 100 and 150 mT for 1, 2 and 3 h and 200 and 250 mT for 1 and 2 h. The required strength of the magnetic field was obtained by regulating the current in the coils of the electromagnet. Gauss meter was used to measure the strength of the magnetic field between the poles.

Germination tests were performed according to the guidelines issued by the International Seed Testing Association (ISTA, 6). Two hundred seeds in four replication of 50 seeds each were placed between two layers of moist germination papers and placed in the germination incubator at 20°C. After 8 days, germination percentage was scored on the basis of radicle emergence from the seed. Ten seedlings from each replicate were taken at random and their shoot and main root length recorded by linear scale. Ten seedlings per replicate were dried in an oven set at 90°C temperature till constant weight was obtained. Seedling vigour was calculated following (Abdul Baki and Anderson, 1) as;

Vigour index I = Germination% × seedling length (root + shoot)

Vigour index II = Germination% × seedling dry weight (root + shoot)

The interactive effect of magnetic field strength and duration of exposure showed insignificant differences in germination percentage of control and treated seeds (data not given). However, all magnetic field doses improved other seedling characteristics namely, length, dry weight and the vigour indices I and II over the unexposed control. The improvement over untreated control seeds was 10.6 to 19.5% for seedling length and 3.8 to 17.8%

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Table 1. Effect of magnetic field exposure of different time intervals on fresh seeds of garden pea (var. Bonneville) along with untreated (control) on different seedling parameters. Values are mean ± SE (n = 40).

Magnetic field (mT)	Time (h)	Seedling length (cm)	Seedling dry weight (g)	Vigour index I	Vigour index II
50	1	25.4 ± 0.78	0.438 ± 0.008	2486.8 ± 96.6	43.0 ± 1.04
	2	26.2 ± 0.78	0.441 ± 0.008	2619.0 ± 77.8	44.1 ± 0.77
	3	26.9 ± 0.40	0.485 ± 0.029	2693.8 ± 39.7	48.5 ± 2.89
100	1	26.9 ± 0.43	0.465 ± 0.002	2677.7 ± 58.1	46.3 ± 0.40
	2	27.0 ± 0.69	0.461 ± 0.006	2668.5 ± 67.2	45.6 ± 0.40
	3	26.8 ± 1.08	0.451 ± 0.011	2677.0 ± 108.1	45.1 ± 1.10
150	1	25.3 ± 0.58	0.442 ± 0.004	2489.9 ± 92.8	43.5 ± 0.73
	2	25.8 ± 0.72	0.436 ± 0.006	2578.0 ± 71.9	43.6 ± 0.65
	3	25.5 ± 0.55	0.433 ± 0.014	2547.5 ± 55.3	43.3 ± 1.43
200	1	25.0 ± 1.10	0.444 ± 0.025	2464.3 ± 108.6	43.8 ± 2.43
	2	27.0 ± 0.75	0.476 ± 0.004	2690.4 ± 81.2	47.3 ± 0.25
250	1	26.9 ± 0.26	0.491 ± 0.007	2677.7 ± 25.8	48.8 ± 0.74
	2	26.7 ± 0.41	0.488 ± 0.016	2630.7 ± 56.4	48.0 ± 1.63
Untreated (control)		22.6 ± 1.34	0.417 ± 0.013	2260.8 ± 134.2	41.7 ± 1.32
CD $\leq$ 0.05		2.18	0.04	231.05	3.86

for seedling dry weight. The calculated vigour indices I and II also increased by 9.0 to 19.2% and 3.2 to 17.2%, respectively (Table 1). Magnetic field induced improvement in the seed germination characteristics have also been reported earlier (Anna, 8; Fischer, 4; Florez, 5). A dose dependent response in seedling parameters was not observed as magnetic doses of 50 mT for 3 h, 100 mT for 1 h and 200 mT for 2 h were more effective than other treatments in increasing most of the seedling parameters. This observation suggested that there may be a resonance like phenomena which increases the internal energy of the seed and that occurs at an appropriate combination of magnetic field and exposure time. Kavi (7) suggested that the internal potential energy of ragi (*Eleusine coracana* Gaertn) seeds changed upon exposure to magnetic field and can be exploited to get higher yields by suitably optimizing the magnetic field and the exposure time.

In another experiment based on the above results, the carry over seeds of 2004 produce of breeder seed of variety 'Bonneville' that was stored at the controlled storage (20°C & 40% RH) facility were exposed to the effective static magnetic field doses of 50 mT for 3 h, 100 mT for 1 h and 200 mT for 2 h and their germination and growth characteristics were investigated. Unexposed fresh seeds (2009 produce) were maintained as control. Twenty-five seeds of untreated control and magnetically treated carry over lot, in four replicates, were soaked in 40 ml of distilled water at 20°C for 6 h and seed leachate conductivity was measured at room temperature (ISTA, 6) using digital conductivity meter (Systronics India).

The results showed that both germination and vigour in terms of seedling length and seedling dry weight increased significantly in all magnetic treatments compared to unexposed aged seeds (Fig. 1a; Table 2a). Among the treatments, 100 mT for 1 h exposure was found to the best and was able to bring back the vigour to the level of fresh seeds. The increase over the unexposed aged seed was 3.5% for germination, 40.3% for seedling length, 35.9% for seedling dry weight. It is the decline in vigour of seeds that is of great concern when seeds are stored for long time and our studies showed that by exposing the 6 year stored seeds to magnetic field, vigour indices I and II improved by 45.4 and 40.9% respectively over the unexposed aged seed (Table 1). Alexander and Doijode (2) observed that onion seeds, conserved for five years, with a viability of 41%, when treated with 108 Oersteds magnetic field strength showed 36.6% increase in germination and significantly improved shoot and root lengths and fresh and dry weights of the resulting seedlings. They also reported that in rice seeds conserved for six years, with very low viability of 8.1%, magnetic

Table 2. Effect of magnetic field exposure on carry over (2004 produce) seeds of garden pea (var. Bonneville) along with unexposed and fresh seeds on different seedling parameters. Values are means ± SE (n = 40).

Treatment	Seedling length (cm)	Seedling dry weight (g)	Vigour index I	Vigour index II
Fresh seed	22.00 ± 1.34	0.417 ± 0.01	2260.80 ± 134.2	41.7 ± 1.32
Unexposed aged	16.36 ± 0.45	0.350 ± 0.02	1563.20 ± 58.4	33.4 ± 1.77
Aged + 50 mT (3 h)	20.26 ± 0.74	0.420 ± 0.01	2006.50 ± 80.8	41.6 ± 1.46
Aged + 100 mT (1 h)	22.96 ± 0.72	0.480 ± 0.03	2271.80 ± 61.0	47.0 ± 2.87
Aged + 200 mT (2 h)	21.90 ± 0.90	0.450 ± 0.01	2088.25 ± 73.7	43.4 ± 1.73
CD ($P \leq 0.05$)	2.700	0.050	259.700	5.350

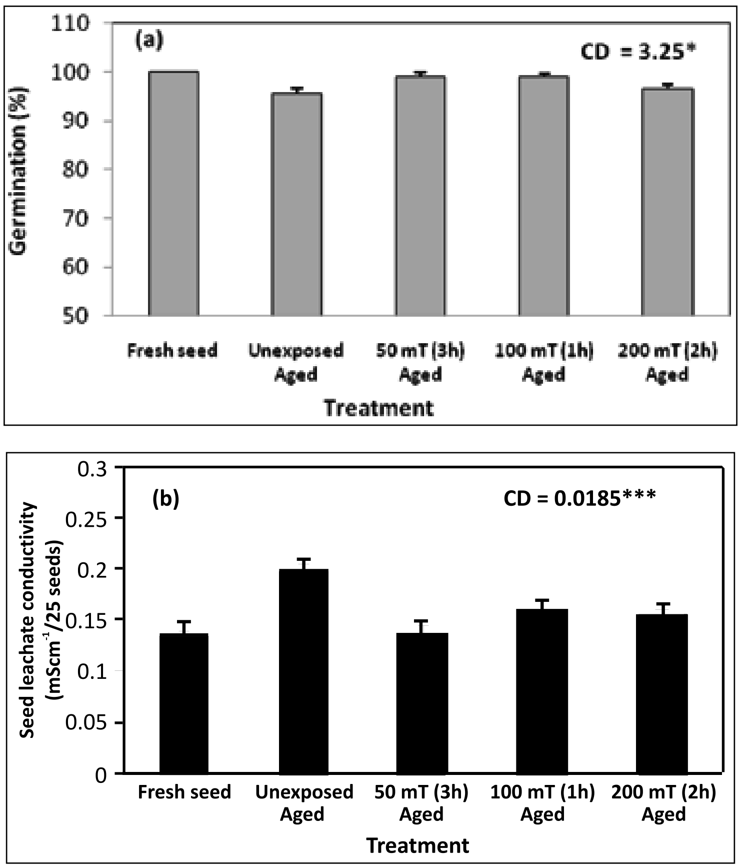

Fig. 1. Effect of magnetic field exposure on carry over (2004 produce) garden pea seeds (var. Bonneville) along with fresh unexposed seeds on (a) Per cent germination (b) Electrical conductivity of seed leachate. The bars indicate the means of 200 seeds per treatment. *** and * indicate significance at p< 0.001 and 0.05, respectively.

field exposure increased germination by 161.5% and improved other seedling characters significantly. In our study with magnetically treated seeds, there was significant reduction (5-13%) in the electrical conductivity of the seed leachate (Fig. 1b). The reduced conductivity of leachate from seeds exposed to 50 mT (2 h), 100 mT (1 h) and 150 mT (2 h) fields compared to unexposed aged seed indicated greater seed coat membrane integrity of these seeds. In the same garden pea variety 'Bonneville', germination and vigour progressively reduced with natural ageing and adversely affected field emergence and seed yield of the crop when aged more than two years (Pandita and Nagarajan, 8). This study clearly shows magnetic treatment of seeds older than two years can reverse the adverse effect of ageing and may improve the productivity of the crop.

Hence, it may be concluded that static magnetic field exposure of 100 mT for 1 h can ameliorate the deterioration caused during storage and improve the germination and vigour of the seedlings. This technique, if standardized for other crop seeds can salvage the costly breeder seed that remain un-lifted due to uncertainty over demand and improve the germination potential of long time conserved seeds in gene banks which otherwise would be discarded due to low viability.

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